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Brief Report

Point-of-care ultrasound diagnosis of small bowel-small bowel vs ileocolic intussusception☆

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ABSTRACT

Background: Identification of intussusception is feasible with emergency department (ED) point-of-care ultrasound (PoCUS) due to its ease-of-use and high accuracy. Little is known about the clinical characteristics and outcomes of small bowel-small bowel intussusception (SB-SBI) relative to ileocolic intussusception (ICI) identified by PoCUS.

Methods: We conducted a retrospective cohort study at a single, tertiary care, urban pediatric ED of intussusception identified by PoCUS. Demographic information, clinical data, and outcomes, including clinical course, intussusception characteristics, recurrence rates, and interobserver agreement (Cohen's kappa), were evaluated.

Results: ED PoCUS identified thirty-seven patients with intussusception over a 4-year period. Twenty-one patients (57%) identified were SB-SBI. The median age was 54 months (IQR 35–76 months) for SB-SBI and 8 months (IQR 5.8–13.5 months) for ICI. The mean diameter was 1.68 cm (SD 0.52 cm) for SB-SBI and 2.74 cm (SD 0.43 cm) for ICI ($p < 0.05$). Two of 21 (9.5%) SB-SBI subjects required surgical intervention, while the rest spontaneously reduced. Fourteen of 16 (88%) ICI subjects required intervention. There were two (9.5%) recurrences of SB-SBI and 1 (6.3%) recurrence of ICI confirmed on PoCUS. Cohen's kappa was 0.85 (95% CI 0.68–1.0).

Conclusions: SB-SBI may be identified more frequently than previously thought when screened with ED PoCUS. Older children with SB-SBI may have underlying lead-points and may require surgical intervention. PoCUS can help differentiate between variants of intussusception that range from a surgical emergency to a transient source of abdominal pain that may be recurrent and otherwise unexplained, allowing clinicians to better manage these patients accordingly.

1. Introduction

Intussusception is the most common abdominal emergency seen in children under two years of age [1]. Intussusception can be divided into two categories: ileocolic intussusception (ICI) and small bowel-small bowel intussusception (SB-SBI). Although ICI is generally thought to be more common, recent studies reveal that SB-SBI may occur more frequently in the pediatric population than previously thought [1-3]. Differentiating ICI and SB-SBI is important as the clinical course and the management of each are different.

While radiology department consultative ultrasound (US) or pneumatic enema is the gold standard for diagnosis of intussusception due to its high sensitivity and specificity, point-of-care ultrasound (PoCUS) use is growing in the emergency department (ED) setting and is often the first-line screening test for suspected intussusception [5-7]. Intussusception is visualized as a “bulls eye” or “target sign” in the transverse plane, or as a “hayfork” or “pseudokidney” in the longitudinal plane on US, representing the multiple layers of bowel wall interposed within each other. Identifying intussusception is a feasible PoCUS application due to its ease of performance and high accuracy and may shorten the ED length-of-stay by decreasing the time to diagnosis and management [5-7]. ICI and SB-SBI have been described and differentiated from one another by their diameter, wall thickness, and length as measured by radiology department US; however, there is scant data regarding the diagnosis of SB-SBI by PoCUS [4-7].

The primary objective of this study was to describe clinical characteristics and outcomes of SB-SBI and ICI identified on PoCUS in pediatric patients, comparing their prevalence, clinical course, ultrasound characteristics, and recurrence rates.

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2. Methods

2.1. Study design

We conducted a retrospective observational cohort study adhering to the STROBE statement at a single, tertiary-care, academic, urban pediatric ED with affiliated residency and fellowship programs including a dedicated Emergency Ultrasound fellowship. This study was approved by our institutional review board. PoCUS was performed based on clinical suspicion for intussusception between November 2014 and March 2019. Our scanning protocol for systematically searching both ICI and SB-SBI began in November 2014. Prior to this date, our protocol was focused only on ICI. All PoCUS were performed by residents, fellows, or faculty members under the supervision of a pediatric emergency medicine (PEM) US attending. Cases were identified independently by the first and the senior authors using the QA tool search function in SoftLink, an US image archiving system (Softlink International Inc., White Plains, NY, USA) in which all PoCUS videos and images were stored. The inclusion criteria for this study were patients found to have intussusception on PoCUS in our ED during this 4-year period. Patients older than 21 years were excluded as they are seen in our adult ED.

Each subject's demographic information, clinical presentation (abdominal pain, vomiting, blood in stool, diarrhea, fever), type of intussusception, other diagnostic imaging (radiology US, abdominal x-ray, CT scan), clinical course, and interventions (air enema, surgical intervention) were obtained from our electronic medical record (EMR) (EPIC Systems Corp., Verona, WI, USA). The diameters of intussusceptions were measured through reviewing PoCUS images stored on SoftLink. Subsequent ED clinical encounters after the subject's initial index ED visit were reviewed in the EMR and assessed for symptoms concerning for intussusception (abdominal pain and/or vomiting). We defined these subsequent ED encounters as confirmed for recurrent intussusception when intussusception was identified by PoCUS or radiology department imaging and unconfirmed when intussusception was not identified on diagnostic imaging or no imaging was performed. Data was manually abstracted from our EMR and entered into a Microsoft Excel (Microsoft Corp., Redmond, WA, USA) database with data elements as described above by the first author and reviewed by the senior author. All PoCUS videos were independently reviewed by a PEM PoCUS expert who was blinded to the diagnosis and clinical course (and was not the sonologist acquiring the images).

2.2. Ultrasound technique

All PoCUS was performed using Fujifilm-Sonosite M-Turbo Ultrasound System (Fujifilm-Sonosite Inc., Bothell, WA, USA) or Mindray TE7 Ultrasound System (Mindray USA Inc., San Jose, CA, USA) using a linear array transducer for young children and curvilinear probe was used for adolescent patients. Patients being evaluated in our ED for intussusception via PoCUS were scanned from the right lower abdominal quadrant to the umbilicus a clock-wise manner to first assess for ICI and then SB-SBI as shown in Fig. 1. PoCUS diagnosis of intussusception was based on identification of a target sign in short axis and a hayfork/pseudokidney sign in long axis (Fig. 2; videolink: https://youtu.be/jxucMXHei5c). SB-SBI and ICI were differentiated from one another by the diameter of intussusception (<2 cm for SB-SBI vs. >2 cm for ICI) and the location of the intussusception (paraumbilical regions for SB-SBI vs. along course of the colon for ICI).

2.3. Statistical analysis

Data were analyzed using Microsoft Excel. Descriptive statistical analyses were used for categorical data. Means were used for normally distributed data and medians were used for non-normally distributed data. Student's *t*-test was used for continuous variables and Fisher exact test was used for categorical variables. Cohen's kappa values were calculated for interobserver agreement of the final diagnosis (SB-SBI vs ICI vs equivocal) between the sonologist performing the ED PoCUS and a second experienced physician sonologist reviewing the films. Cohen's kappa was calculated using an online calculator (http://vassarstats.net/kappa.html).

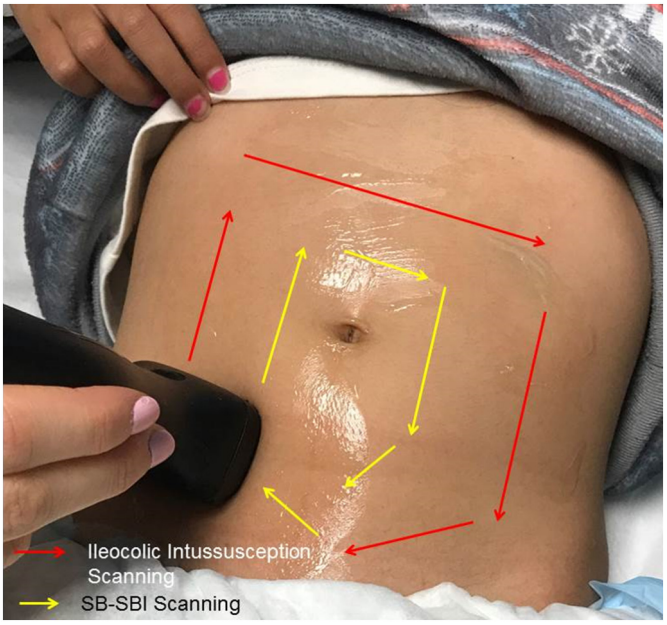

Fig. 1. PoCUS scanning technique.

3. Results

Thirty-seven subjects were identified to have intussusception on PoCUS between November 2014 and March 2019. Patient demographic and clinical characteristics are presented in Table 1. Twenty-one subjects (57%) identified were diagnosed with SB-SBI based on PoCUS and clinical course in the ED. There were no missing demographic or clinical data abstracted from our EMR in the 37 cases. The median ages were 54 months (IQR 35 to 76 months) for SB-SBI and 8 months (IQR 5.8 to 13.5 months) for ICI. All but 4 patients with SB-SBI underwent radiology department US following PoCUS diagnosis of intussusception.

Clinical differences between SB-SBI and ICI are presented in Table 2. The mean diameter was 1.68 cm (SD 0.52 cm) in the SB-SBI group and 2.74 cm (SD 0.43 cm) in the ICI group. Nineteen of the 21 SB-SBIs (90%) resolved spontaneously and 2 required surgical reduction. The 2 surgical subjects were both adolescents found to have pathologic lead-points on pathology: a 16-year-old male had a benign adenoma and an 18-year-old female had a lipoma. A third adolescent patient had Henoch-Schonlein purpura but her intussusception reduced without intervention. These 3 patients had their SB-SBI confirmed by radiology department US while the rest all resolved prior to radiology US. Two of 16 patients with ICI (13%) reduced spontaneously. Ten ICIs (63%) were successfully reduced by air enema and 4 (25%) required surgical reduction after unsuccessful air enema.

Two SB-SBIs recurrences were confirmed on PoCUS. The first case recurred 4 months after the initial episode in a 3-year-old female, and the second case recurred 1 year after the initial episode in a 6-year-old female. In these patients, both the first and second episodes resolved spontaneously. Three patients returned to the ED with abdominal pain and/or vomiting suggestive of intussusception within a variable timeframe (1 day to >1 year), but no PoCUS or radiology US was performed during these encounters. Two patients had recurrence of ICI (requiring multiple repeat air enemas) identified on radiology US within

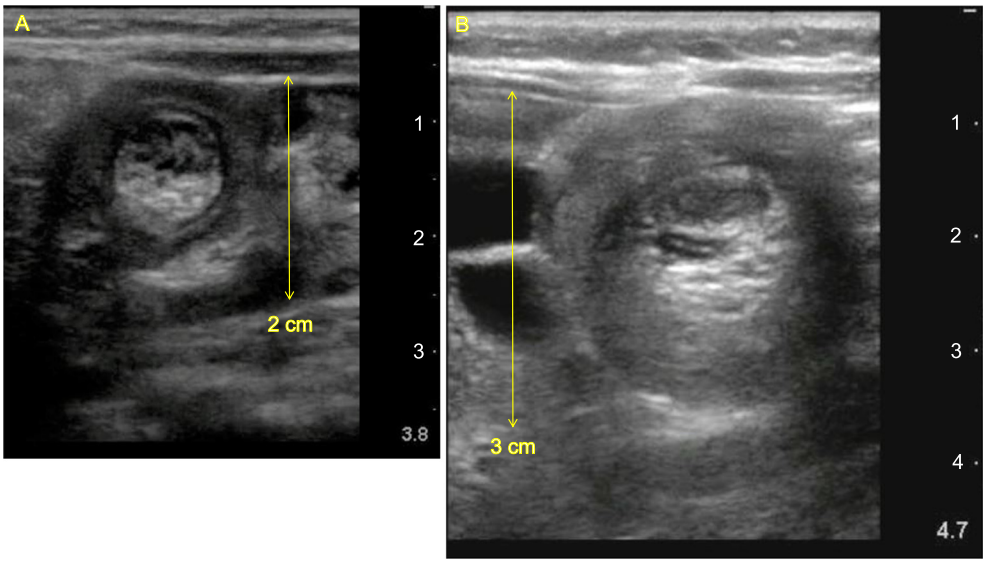

Fig. 2. "Target sign" short axis views: Panel A - SB-SBI; Panel B – ileocolic intussusception.

minutes to hours after successful initial air enema. One patient had a recurrence of ICI 4 days after a successful air enema that was identified on PoCUS and radiology US and required a repeat enema reduction. No subject had a recurrence with a different type of intussusception.

Interobserver agreement for diagnosis of SB-SBI vs ICI as measured by Cohen's kappa between the initial sonologist's interpretation and the second sonologist's interpretation of the videos was 0.85 (95% CI 0.68–1.0). All discrepancies between final diagnosis (initial PoCUS interpretation combined with clinical course by chart review) involved SB-SBI versus equivocal for intussusception; there were no discrepancies involving ICI.

4. Discussion

SB-SBI was identified more frequently than ICI in our cohort when using PoCUS as a screening tool. To our knowledge, this has not been previously reported in the ED PoCUS literature. This may be attributed to rapid detection by PoCUS, a lower threshold to search for intussusception afforded by PoCUS, or both. Other studies utilizing radiology department US have shown varying prevalence of SB-SBI, ranging from <10% to >50% of all intussusceptions documented at their respective institutions. [1-3] Overall, the prevalence of SB-SBI appears to be rising due to increase in routine use of abdominal US for children with abdominal pain [10]. Moreover, given the self-resolving nature of SB-SBI, detection may be dependent on how quickly the patient presents to the ED and how quickly US can be performed during the encounter.

Table 1
Patient demographics and clinical characteristics.

Characteristics	Study cases (n = 37)
Median age at presentation, months (IQR[a])	30 (7–61)
Sex	
Male, n (%)	17 (46)
Female, n (%)	20 (54)
Signs/symptoms	
Abdominal pain, n (%)	37 (100)
Vomiting, n (%)	20 (54)
Blood in stool, n (%)	9 (24)
Diarrhea, n (%)	5 (14)
Fever, n (%)	6 (16)

[a] IQR – interquartile range.

There was a statistically significant difference in the ages between the two groups with the SB-SBI group being older and having a wider age range than the ICI group. The ICI group was predominantly <1 year of age while the SB-SBI group was largely older than 1 year of age, appearing consistent with known epidemiologic data for these 2 groups [2,4,9]. The oldest patient with SB-SBI was an 18-year-old female who required surgical resection of the affected bowel and was found to have a lipoma as a pathologic lead-point. The second oldest patient with SB-SBI was a 16-year-old male who also required surgical resection and was found to have a benign adenoma as a pathologic lead-point. Although it has been shown that older children (>5 years old) with ICI are likely to have pathologic lead-points, there is little data regarding SB-SBI [8]. Similar to older children with ICI, adolescents in our series with SB-SBI were more likely to have pathologic lead-points requiring operative intervention compared

Table 2
Small bowel-small-bowel intussusception compared to Ileocolic Intussusception

	SB-SBI (n = 21)	ICI (n = 16)	*p*
Median age, months (IQR[a])	54 (35–76)	8 (5.8–13.5)	0.0056
Gender			
Male, n (%)	10 (48)	7 (44)	n/a
Female, n (%)	11 (52)	9 (56)	n/a
Signs/symptoms			
Vomiting, n (%)	16 (76)	14 (88)	0.675
Blood in stool, n (%)	2 (9.5)	7 (44)	0.024
Diarrhea, n (%)	4 (19)	1 (6)	0.364
Fever, n (%)	4 (19)	2 (13)	0.680
Intussusception			
Mean diameter, cm (SD[b])	1.68 (0.52)	2.74 (0.43)	<0.0001
Clinical course			
Self-resolution, n (%)	19 (90)	2 (13)	<0.0001
Enema reduction, n (%)	0 (0)	10 (63)	<0.0001
Surgical reduction, n (%)	2 (9.5)	4 (25)	0.371
Healthcare revisits-confirmed, n (%)	2 (9.5)	1 (6)	n/a
Healthcare revisits confirmed and unconfirmed, n (%)	6 (29)	3 (19)	0.702

[a] IQR – interquartile range.
[b] SD – standard deviation.

to younger children. Excluding these cases, SB-SBIs in our cohort were transient and without further complications which was consistent with our current understanding of SB-SBI [3,10,11].

Diameter differences between the two groups were statistically significant. All SB-SBI were under 2 cm in diameter except for 5 subjects who were 18, 16, 16, 9, and 3 years old. All ICI were >2 cm in diameter. These numbers are consistent with a large retrospective study using radiology US that compared SB-SBI and ICI [9]. Differentiating SB-SBI from ICI ultimately requires corroborative data such as the location of intussusception and age, as size will not always be a reliable differentiating marker. This is especially true in older children or adolescents with SB-SBI larger than 2 cm as seen in our cohort. The only statistically significant difference in the presenting symptoms was bloody stools which was more common in the ICI group. Twenty-five percent (n/N = 4/16) of ICI patients in our cohort required surgical intervention which is similar to that reported by Reira et al. (n/N = 5/13: 38%; 95% CI: 15–68) [7].

There were 2 US-confirmed recurrences of SB-SBI and 3 unconfirmed recurrences in our cohort. The first patient was a 3-year-old female whose SB-SBI was seen on both PoCUS and radiology US and spontaneously resolved during serial US exams. She returned to the ED 4 months later with another spontaneously reducing SB-SBI confirmed on PoCUS and radiology US. The second patient was a 6-year-old female who presented to the ED almost 1 year after a self-resolved SB-SBI diagnosed on PoCUS with similar abdominal pain and was found to again have SB-SBI on PoCUS. Her symptoms quickly improved during her ED stay and her SB-SBI had resolved by the time further diagnostic imaging was performed. She then presented to the ED approximately another year later with a third episode of similar self-resolving abdominal pain where she was discharged without any diagnostic imaging and referred to pediatric gastroenterology clinic. In the limited published data, the recurrence rate and time after initial diagnosis of SB-SBI appears to be varied with one study showing recurrences from 1 day to 1 year after the initial episode with spontaneous reduction [11]. Rate of recurrence of SB-SBI may be higher but not captured on diagnostic imaging due to its transient nature.

Interobserver agreement measured by Cohen's kappa was high. While there were disagreements between the two physicians regarding SB-SBI versus equivocal, there were no disagreement regarding ICI versus SB-SBI and ICI versus equivocal.

4.1. Limitations

Our study was limited by its retrospective design; however, it is unlikely that cases of intussusception diagnosed by PoCUS were missed as all PoCUS images obtained or supervised by credentialed PoCUS faculty were archived. In addition, it is possible that patients with self-resolving SB-SBI presented to our ED when no credentialed faculty was present to perform PoCUS; however, to our knowledge, there were no missed intussusception (PoCUS negative, Radiology US positive) based on our Pediatric ED 72-hour return quality assurance during this study period. Our single center results may not be generalizable to other similar acute care settings, but to our knowledge this is the first and largest descriptive cohort of SB-SBI diagnosed by PoCUS relative to ICI. Additionally, follow-up and estimates of recurrences were limited to review of additional healthcare visits within our multi-hospital health system EMR. As follow-up periods were variable among patients depending on time of diagnosis, our data was subject to lead-time and length-time biases. As ED PoCUS was often the only diagnostic evidence of SB-SBI with no other feasible method for confirmation, images were reviewed and confirmed by a second PoCUS expert blinded to the diagnoses. Future prospective studies are needed to provide more accurate population-based estimates of the relative proportion of SB-SBI diagnoses and recurrences relative to ICI by ED PoCUS.

5. Conclusions

SB-SBI may be identified more frequently than ICI in children presenting to the ED with abdominal pain when screened with PoCUS. PoCUS may be helpful in differentiate between variants of intussusception that range from a surgical emergency to a transient source of abdominal pain that may be recurrent and otherwise unexplained.

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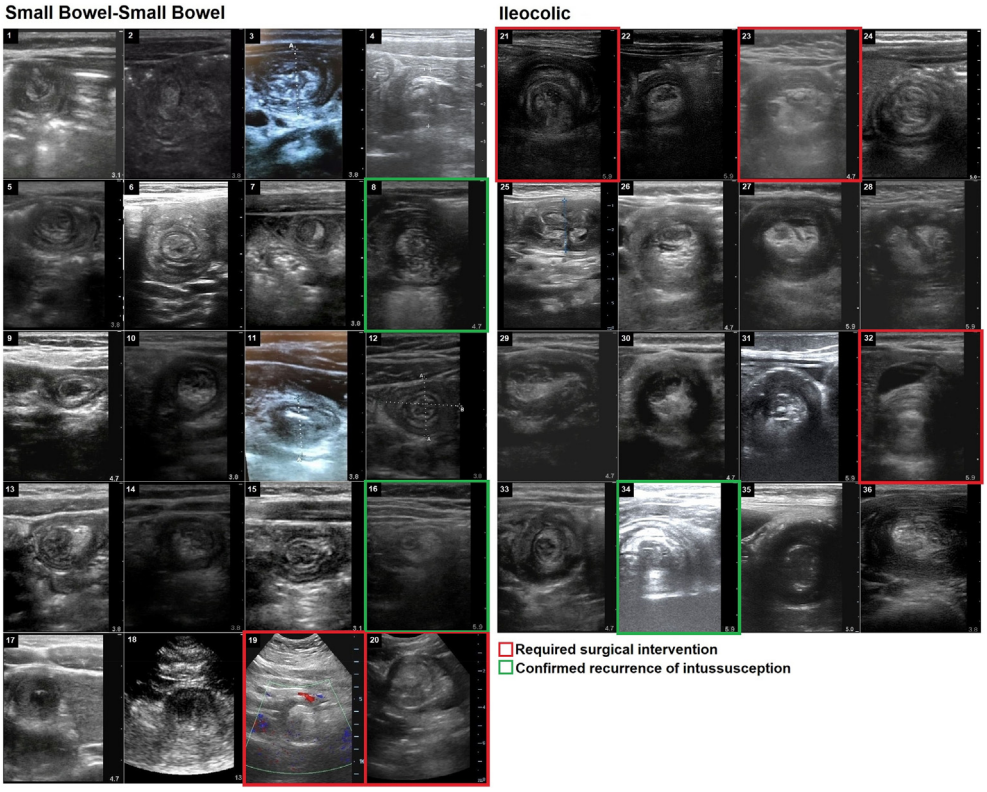
Declaration of Competing Interest

The authors have no conflicts of interest to disclose.

Appendix A



Appendix 1. PoCUS images of all study patients. Red frames required surgical reduction. Green frames experienced recurrence of intussusception.

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